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ANACAPA ISLAND SPLIT PIPE INSTALLATION INSPECTION AND REPAIR, 1--ETC(U)

FEB 80 W R TAUSIG, R L BRACKETT

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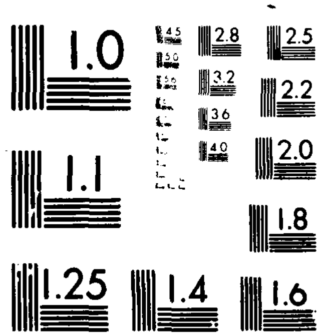

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The U. S. Navy currently maintains and operates numerous underwater power and signal cables. Most of these cables utilize split pipe systems to protect the cable from damage in the surfzone and when crossing exposed rocky seafloors. Past experience has shown that the hardware used to install the split pipe system lacks the reliability and maintenance-free operation required for the life of the cables. Based on previous experience with cable failures, the areas determined to be in greatest need of investigation are fasteners for holding

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The U. S. Navy currently maintains and operates numerous underwater power and signal cables. Most of these cables utilize split pipe systems to protect the cable from damage in the surfzone and when crossing exposed rocky seafloors. Past experience has shown that the hardware used to install the split pipe system lacks the reliability and maintenance-free operation required for the life of the cables. Based on previous experience with cable failures, the areas determined to be in greatest need of investigation are fasteners for holding the split pipe halves together, immobilization of the pipe, and cathodic protection for the entire system. As a result, CEL tested prototype and commercially available hardware components which appeared to be suitable replacements for the existing split pipe hardware. The candidate hardware was then used in a 300-foot-long test section of split pipe installed March 1976 at Anacapa Island, to be inspected during a five-year period. This report presents the results of the October 1978 inspection conducted 2-1/2 years after installation of the test system. Also discussed is the repair operation conducted in March 1979 to replace those sections of split pipe which were damaged during a severe storm in January 1978.

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1.0 INTRODUCTION

Underwater power and signal cables are of great importance to the Navy. In most cases, split pipe systems are used to protect these cables from damage in the nearshore and surfzone regions. However, experience has shown that hardware used in installing these split pipe systems is often unreliable. Previous attempts to improve the hardware have been confined to in the field trial and error procedures using off-the-shelf components.

Under the sponsorship of the Naval Facilities Engineering Command (NAVFACENGCOM), a project was undertaken in July 1974 by the Civil Engineering Laboratory (CEL) to develop improved hardware and methods for the maintenance and repair of existing split pipe protected cables. To meet this objective, CEL investigated different types of fasteners for holding the split pipe together, methods for immobilization of the cable, and methods for cathodically protecting the entire system. The hardware components that showed promise during laboratory tests were then used in a 300-foot-long open ocean test installation on the south side of Anacapa Island, California. These components are being inspected and monitored approximately semi-annually for a five-year period.

2.0 BACKGROUND

Results of the CEL hardware tests, the March 1976 Anacapa split pipe installation procedures, and the first long-term inspection are documented in CEL Technical Note N-1498 (reference 1). The second and third pipe inspections were made in June 1977 and April 1978. Results of these inspections are documented in CEL Technical Note N-1525 (reference 2).

During the inspection of April 1978, pipe sections 2 through 10 were found to have been damaged by severe wave action and were dislodged from the remainder of the pipe installation. The damage was due to failure of the fasteners in these sections to hold the split pipe halves together. Table 1 shows the position of the test fasteners as they were originally installed. Pipe section 1 was found still rock-bolted to the shore. Pipe sections 11 through 98 were still intact (at a water depth from 10 feet out to 40 feet). During a return trip in May 1978, pipe sections 2 through 10 were recovered and brought back to CEL for failure analysis. The complete failure analysis is described in reference 2. Results of this analysis indicated that the primary cause of pipe damage was due to fastener failure initiated by the loss of the cathodic protection system. Pipe sections 2 through 5 contained stainless steel Hi-Shear fasteners. Failure of these fasteners was caused by corrosion and enlargement of the cast iron pipe flange holes due to the galvanic interaction between the pipe and the stainless steel fasteners. The cast iron pipe was cathodically protecting the stainless steel fasteners causing the holes to enlarge and allowing the fasteners to slip through.

Table 1. Position of Fasteners as of June 1977.

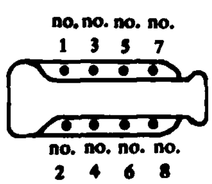
Section	Flange Holes			Section	Flange Holes		
	1-4,7,8	5	6		1-4,7,8	5	6
1	MB	RB	RB	31	HB(1,4L), 3MB,7MB	RB	RB
2	HB	RB	RB	32	HB(7L)	SB	MB
3	HB	RB	RB(L)	33	HB	MB	MB
4	HB	MB	MB	34	HB(3L)	MB	MB
5	HB	MB	MB	35	HB(2L)	MB	MB
6	HG	MB	MB	36	HG(2L)	SB	MB
7	HG	MB	MB	37	HG	MB	MB
8	HG	MB	MB	38	HG	MB	MB
9	HG(2L)	MB	MB	39	HG(1,2L)	MB	MB
10	HG	MB	A	40	HG(1L)	MB	MB
11	BOM	BOM	BOM	41	BOM	MB	MB
12	BOM	MB	MB	42	BOM	MB	MB
13	BOM	MB	MB	43	BOM	RB	RB(L)
14	BOM	MB	MB	44	BOM	HB	HB
15	BOM	RB	RB	45	BOM	HB	HG
16	HB	MB	MB	46	HB(1L)	RB	RB
17	HB	MB	MB	47	HB(2,7L)	HB	HB
18	HB	MB	MB	48	HB(4L)	HB	HB
19	HB	MB	MB	49	HB(7L)	HB	HB(L)
20	HB	HB	MB	50	HB	HG	AN
21	HG	MB	MB	51	HG	–	–
22	HG	MB	MB	52	HG	HB	HB
23	HG	MB	MB	53	HG	HB	HB
24	HG	MB	MB	54	HG	–	–
25	HG	MB	MB	55	HG	HG	HB
26	BOM	MB	MB	56	BOM	HB	HG
27	BOM	MB	MB	57	BOM	HB	HG
28	BOM	RB(L)	RB	58	BOM	HB	HB
29	BOM	MB	MB	59	BOM	HB	HB
30	BOM	MB	A				

continued

Table 1. (Continued)

Section	Flange Holes		
	1-4,7,8	5	6
60	BOM	HGL	HB
61	HB	RB	RB
62	HB(2,3,7L)	HB	HG
63	HG	HG	HG
64	HB(7L)	–	–
65	HB(8L)	HG	HB
66	HG	HG	HB(L)
67	HG	HG	HB
68	HG	HG	HG
69	HG,1MB(L)	HG	HG
70	HG,1MB(L)	–	AN
71	BOM	HG	HG
72	BOM	HB	HG
73	BOM	HB	HG
74	BOM	–	HG
75	BOM	RB	HG
76	HB	–	HB
77	HB,1MB	–	–
78	HB(4,7,L)	HB	HB(L)
79	HB(4L)	RB	RB
80	HB	HB	HB
81	HG	HB	HB
82	HG	–	–
83	HG	HB	HB
84	HG,1SB	–	–
85	BOM	HB	HB
86	BOM	HB	HB
87	BOM	RB	RB
88	BOM	HB	RB
89	1,2,3,7,BOM	HB	–
90	HB	HB	AN
91	HB(1L)	HB	HB
92	HB	–	–
93	HB(1L)	–	–
94	HG	–	HB
95	HG	HB	HB
96	HB	HB	HB
97	HG	MB	HB
98	HG	RB	RB

BOM – Huck fastener
SB – Stainless steel nut and bolt
HB – Hi Shear stainless steel
HG – Hi Shear mild steel
MB – Mild steel nut and bolt
(L) – Fastener loose
RB – Rock bolt
AN – Anode attached with stainless nut and bolt



Pipe sections 6 through 10 contained mild steel Hi-Shear fasteners. Failure of these fasteners was caused by corrosion of the fasteners themselves inside of the cast iron flange holes. The diameter of these fasteners was reduced by corrosion enough to allow them to slip through the pipe flange holes. In addition, all of the mild steel nuts and bolts originally used in sections 2 through 10 were missing, primarily due to vibration loosening. The only fasteners that remained intact were the BOM fasteners beginning with pipe section 11. The BOM fasteners even though fabricated from mild steel, maintain their mechanical integrity longer in the ocean environment due to their larger swaged end. This larger swaged end resists slippage caused by the decrease in diameter from corrosion.

3.0 INSPECTION OF OCTOBER 1978

On October 26, 1978, the fourth of ten planned inspections was conducted on the remaining undamaged split pipe at the Anacapa Test Site. Visual inspection of the pipe installation revealed continued deterioration of the cathodic protection system coupled with heavy marine growth.

3.1 Effects of Cathodic Protection

Standard galvanic potential readings were taken with an underwater voltmeter on each pipe section. Results of these readings, together with the readings taken on the two previous inspections, are presented in Figure 1. These results show that the cathodic protection system continued to deteriorate. This deterioration is primarily caused by the increasing number of failed jumper cables that were broken or missing between pipe sections 10 through 27, 29 and 30, 34, through 37, 39 through 41, 44 and 45, 59 and 60, 85 through 87, and 96 and 97. Only pipe sections 60 through 74 were cathodically protected by the anode located at pipe section 70. All of the other remaining pipe sections were unprotected.

3.2 Effects of the Marine Growth

Visual inspections of the pipe sections and fasteners revealed heavy marine growth. In many cases the pipe fastener type could not be identified without first brushing away the growth. Only the fasteners of pipe sections located in the sandy bottom areas are free of heavy growth. This is primarily due to the abrasion effect of the moving sand.

3.3 Effects of Hydrodynamic Forces and Immobilization

Inspection of the pipe installation revealed that, other than pipe sections 1 through 10 destroyed previously by a storm, no further pipe damage was suffered due to hydrodynamic forces. All rockbolts beyond pipe section 11 were found intact.

3.4 Effects of Corrosion

Visual inspection of the pipe fasteners for the undamaged pipe sections 11 through 98 revealed no evidence of failure due to corrosion. All of the remaining fasteners, including the BOM fasteners beginning with pipe section 11, continued to hold the pipe assemblies together.

4.0 ANACAPA SPLIT PIPE REPAIR

4.1 Objective

An operational plan was developed to repair the Anacapa split pipe installation in March 1979 and continue the evaluation of the fastener systems. The primary objectives of the split pipe repair were: (1) to replace the shore end of the pipe installation destroyed by the storm waves, (2) evaluate the performance of the BOM fastener under the severe conditions encountered at the shore end of the test system, and (3) evaluate the performance of an improved cathodic protection system design.

4.2 First Day of Repair

On March 5, 1979, the split pipe installation was surveyed and prepared for the repair work. The dive/work boat was first placed into a 3-point moor by dropping the bow and stern anchor and tying off to the island. Figure 2 shows the 3-point moor. In this manner, the dive boat could be maneuvered close to the island directly over the pipe installation and be used as the work platform for the hydraulic tools. A padeye plate was then rockbolted in place to the island. This plate was to be used as a future anchor point for the dive boat, and also for holding a pulley block for pulling split pipe on shore. Four holes were drilled into the rock with the hydraulic rockdrill. Rockbolts were then installed to hold the padeye plate in place. Figure 3 shows the installation of the padeye plate.

Pipe sections 11 through 98 were then surveyed and found to be intact. In addition, pipe section 11 was still located in the correct position for mating with the new repair sections. Pipe section 1 was reovered. It had been dislodged and was found lying next to pipe section 11.

Pipe section 11 was then prepared to receive the new string of repaired pipe. To do this, pipe section 11 was disassembled by first grinding off the heads of the BOM fasteners and punching them out of the pipe flange. Figure 4 shows the divers grinding off the fasteners with the hydraulic grinder. Work in this area was time-consuming because of the large amount of surge in the surfzone. Total time for grinding and removing the 8 BOM fasteners from pipe section 11 was 1-1/2 hours. After opening pipe section 11, the tangled end of the multiconductor cable was cut back using the hydraulic bandsaw and wire cutters. Pipe section 11 was finally bolted back together with standard nuts and bolts. This was

done so that pipe section 11 would remain attached to pipe section 12 and could also be easily disassembled at a later date when mating to the repair sections.

4.3 Second Day of Repair

On March 6, 1979, twelve repair sections of pipe were assembled in Port Hueneme on the dock alongside the LCM-8 dive boat. These were numbered sections 1 through 10 as before, with two additional pipe sections on the shore end, lettered A and B. All of the repair sections were assembled with BOM fasteners as shown in Figure 5. (This will provide a long-term evaluation of the BOM fasteners under the severe conditions existing at the shore end). The entire pipe assembly was then tied to the side of the dive boat, with two float balloons tied to each pipe section. The repair scenario was to cut the pipe assembly from the dive boat at the repair site, and cut the float balloons once in position. Figure 6 shows the repair assembly tied off to the dive boat.

4.4 Third Day of Repair

On March 7, 1979, the dive boat proceeded to the split pipe installation site at Anacapa Island. Once again the boat was put into a 3-point moor using the bow and stern anchors, and the padeye plate on shore. The repair pipe assembly was then cut loose from the dive boat and floated to shore. The shore end of the repair section was pulled onto shore by a line attached to pipe section A, through the pulley block at the padeye plate, and around a gypsy head winch on the dive boat. The seaward end of the floating pipe assembly was positioned using an inflatable boat. Figure 7 shows the repair work in progress. After positioning the shore end of the repair assembly, the float balloons were removed, dropping pipe section 10 to mate with section 11. A come-a-long between the two pipe sections helped to line up the assembly. These two pipe sections were temporarily connected using the nuts and bolts on section 11. Ten rockbolts were then installed to stabilize as many of the repair sections (above and below water) as possible. Finally the nuts and bolts in pipe section 11 were replaced with 8 BOM fasteners, using the hydraulic installation tool. Table 2 shows the repair and final fastener location of the new pipe installation.

4.5 Improved Cathodic Protection System

The failure analysis for the previously damaged pipe sections (reference 2) identified the cause of failure as being initiated by the loss of cathodic protection. In addition, the weakest point in the cathodic protection system was identified as the jumper/anode cables and their terminations on the split pipe. In an attempt to improve this weak point, a new jumper system was designed for evaluation.

Table 2. Position of Fasteners (Repaired Pipe) as of March 1979

Section	Flange Holes		
	1-4,7,8	5	6
A	RB(1,2) BOM	RB	RB
B	BOM	RB	RB
1	BOM	RB	RB
2	BOM	RB	RB(L)
3	BOM	-	-
4	BOM	-	-
5	BOM	-	-
6	BOM	-	-
7	BOM	-	-
8	BOM	-	-
9	BOM	-	-
10	BOM	-	-

NOTE: Sections 11-98 are the same as shown in Table 1.

The new jumper system for the Anacapa tests consists of arc-welding 1/2" studs on the bell end and socket end of each pipe section respectively. Jumper grounding straps were then fastened between each stud. The straps themselves are heavy duty automotive-type grounding straps with heavy duty terminations. Each strap is made up of 1/2" wide copper braid, which is more flexible yet stronger than the previous jumper cables.

For use in normal split pipe systems, the new jumper straps may be attached to the pipe fastener during the installation process without requiring the underwater welding operation.

In September 1979, the repair team of CEL divers began to install the new jumper system. The process consisted of first grinding a clean area on each pipe section's bell and socket using the hydraulic grinding tool. Figure 8 shows a diver using a hydraulic grinder on the split pipe. Next, the 1/2" jumper studs were arc-welded onto each of the cleaned pipe areas (Figure 9). During the first day, using the new repair technique, jumper straps were successfully connected to pipe sections 32 through 46. Figure 10A shows a detail of the jumper strap. Figure 10B shows an overall view of the pipe line with jumpers. In addition, two anodes were connected to the repaired system; one to pipe section 34 and one to section 42. Each anode weighed 57 pounds in water at the time of attachment. With the addition of the new jumper straps together with the remaining undamaged jumper cables, pipe sections 27 through 52 are currently connected within the cathodic protection system.

All remaining jumper cables will be replaced by jumper straps in FY80.

5.0 CONCLUSIONS

1. Even without a cathodic protection, the BOM fasteners have continued to maintain mechanical integrity of the Anacapa test system for over 3-1/2 years.

2. For replacing jumper straps on existing pipe systems, welding studs onto the bell and socket pipe areas and connecting straps between studs is a feasible method of repair.

3. Although the BOM fasteners were successfully removed from the split pipe using a hydraulic grinder, the length of time required for this operation (1-1/2 hours/section of pipe) reinforces the requirement to develop an efficient blind bolt removal technique.

6.0 REFERENCES

1. Brackett, R. L., and Tausig, W. R. (1977) Improved Hardware and Techniques for Maintenance and Repair of Split Pipe Protected Cables, Civil Engineering Laboratory. Technical Note N-1498, Port Hueneme, CA, August 1977.

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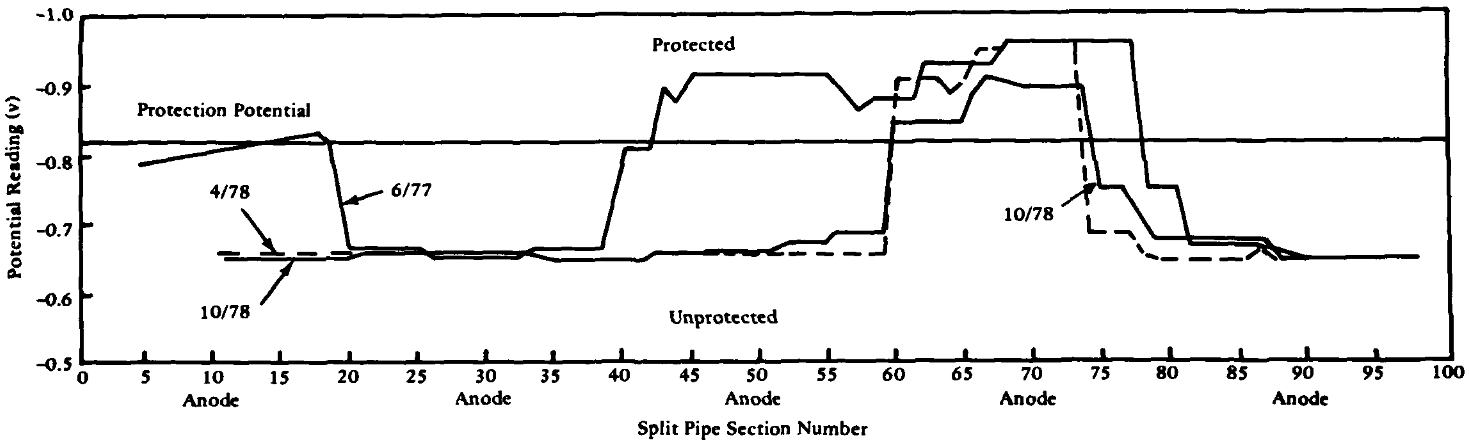

Figure 1. Cathodic protection potential.

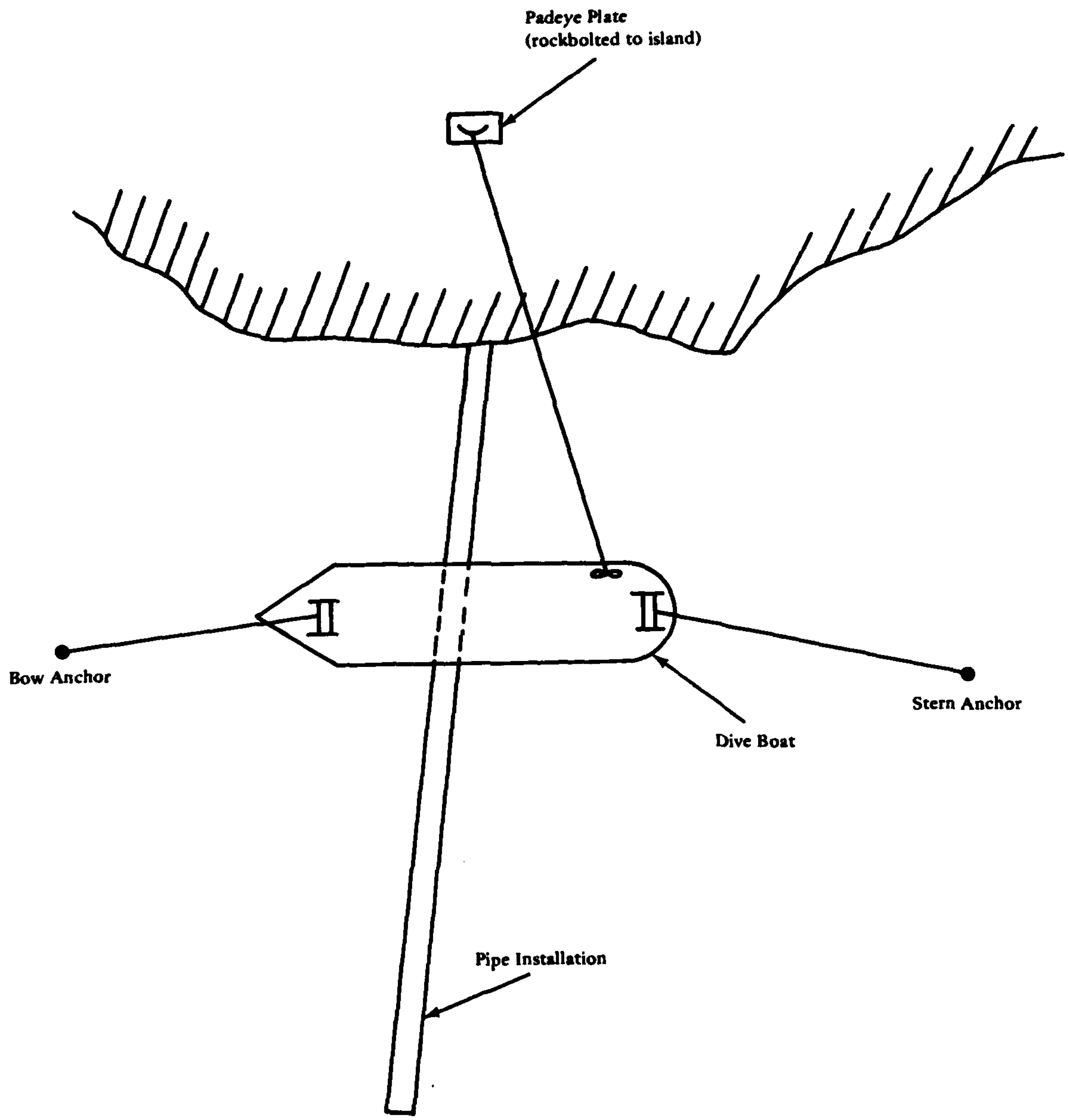

Figure 2. Three-point moor.

Figure 3. Installation of padeye plate.

Figure 4. Removal of BOM fasteners using an hydraulically powered grinder.

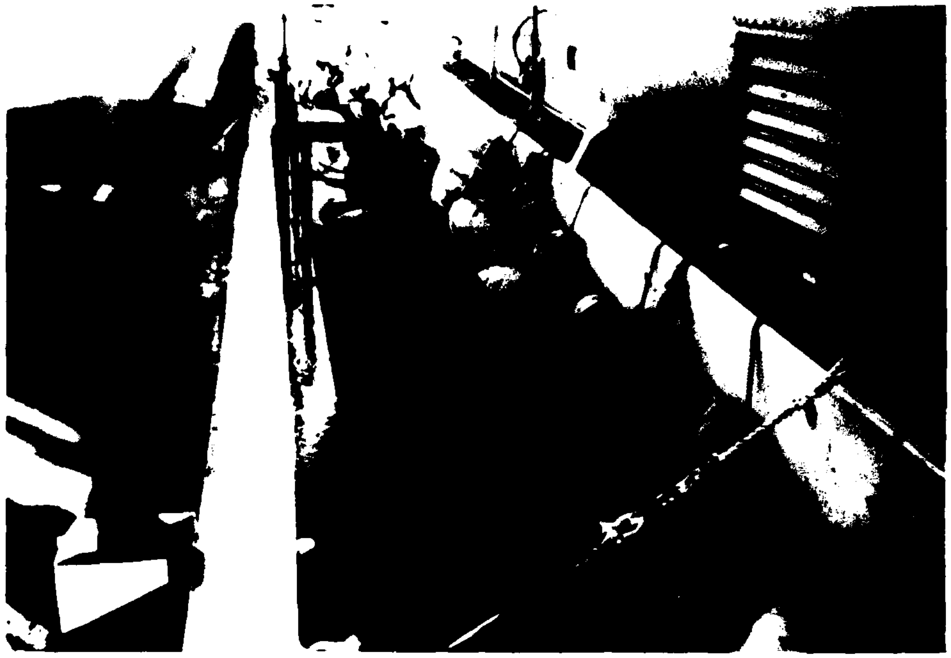

Figure 6. Repair pipe ready for transport to test site.

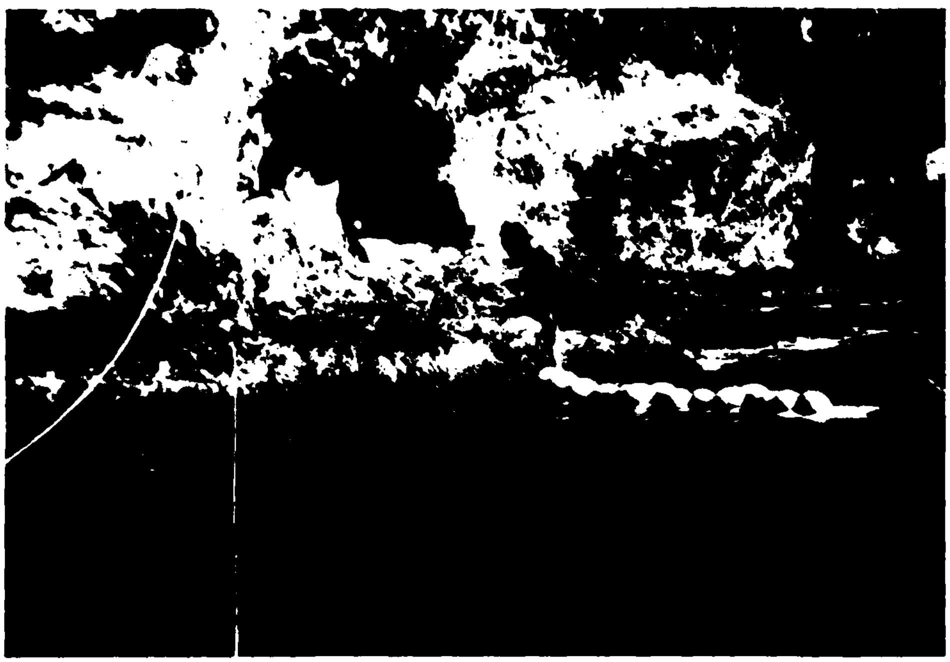

Figure 7. Repair pipe sections floated into position.

Figure 5a. Assembling repair sections of split pipe using BOM fasteners.

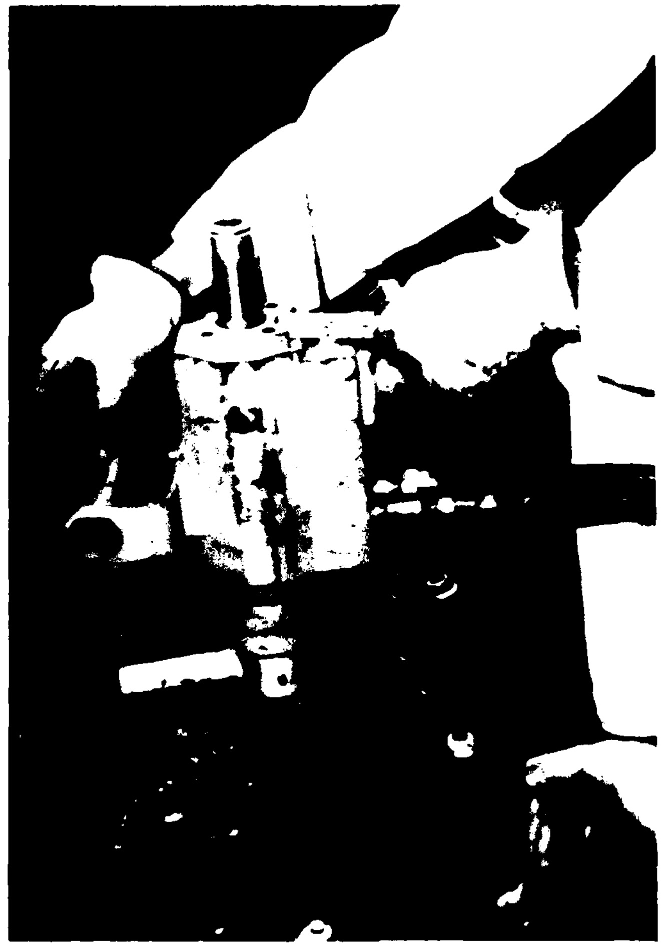

Figure 5b. Fastener installation tool.

Figure 8. Preparing split pipe for welding using hydraulic grinder to clean surface.

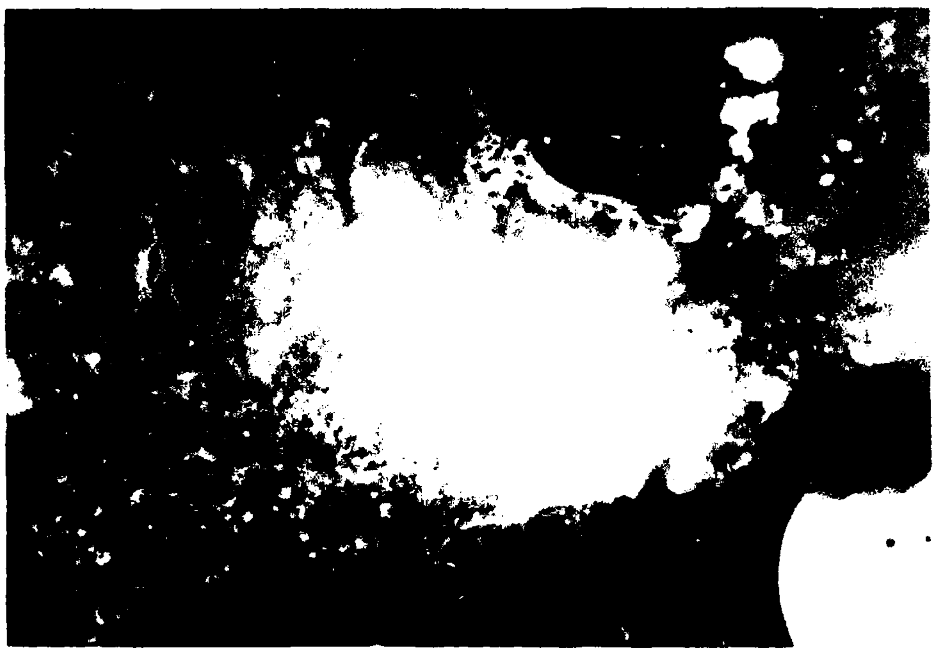

Figure 9. Arc welding 1/2-in. diameter studs to split pipe.

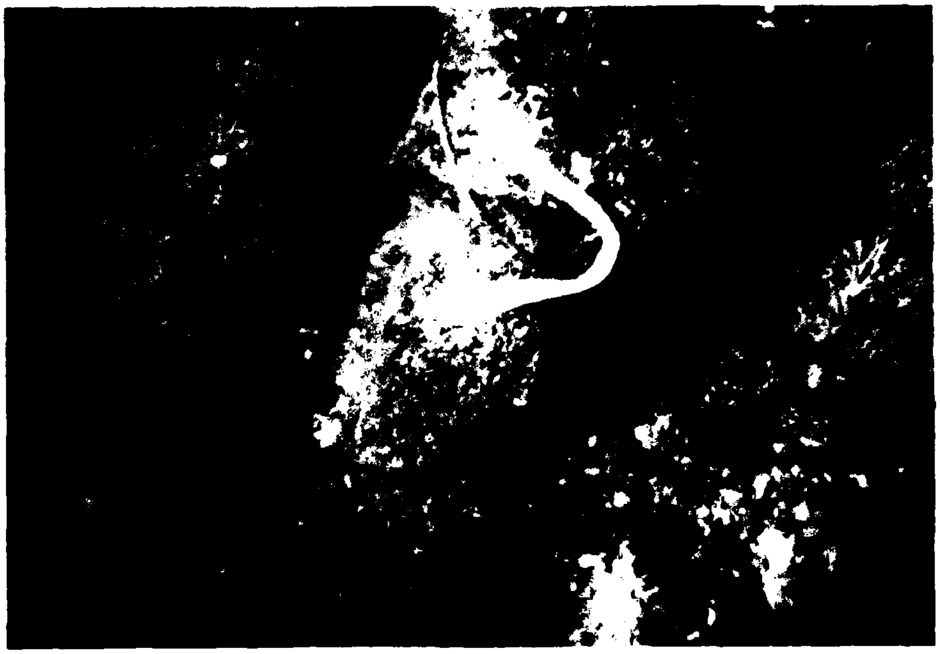

Figure 10a. Detail of new jumper strap installation.

Figure 10b. Completed jumper installation.

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